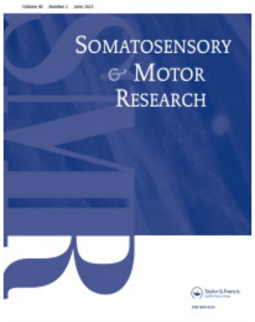

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ARTICLE

Brain gym exercises improve Eye-Hand coordination in elderly males

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ABSTRACT

Background and purpose: Understanding the issues of the elderly or providing opportunities for a more fruitful ageing are some of the challenges that the officials and researchers in the area grapple with. The current study aimed to investigate the effectiveness of a series of brain gym exercises on elderly males' eye-hand coordination.

Material and Methods: Thirty old males (60–80 years old) were selected using the convenience sampling technique and were divided equally into an experimental and a control group. After performing baseline measurements, the experimental group performed the brain gym exercises for 16 sessions; the sessions were held twice in week, and each session lasted for 30 min. The touch test disc was applied to assess the participants' eye-hand coordination.

Results: The results of mixed-ANOVA indicated a significant difference between the experimental and control groups ($p < 0.05$) and in favour of experimental group.

Conclusion: The results were quite promising and have practical implications for the exercise and routine programs of rehabilitation centres and nursing homes. However, the limited research studies conducted in the area make use recommend conducting more studies using larger samples of both genders and exploiting other tasks of eye-hand coordination.

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Motor performance; touch disc; brain gym; coordination; elderly

Introduction

Despite having different rates among individuals, ageing is an almost inevitable stage of a person's life and mostly included a progressive and gradual decline in his/her physical and mental capacity and the increased risk of various illnesses typically due to a series of biological and environmental factors (e.g., Balducci 2007). Thus, understanding the issues of the elderly or providing opportunities for a more fruitful ageing are some of the challenges that the officials and researchers in the area grapple with (Wang and Blazer 2015). Taking part in physical activities leads to slower declines in their sensorimotor functions (e.g., Van Halewyck et al. 2015). For instance, some studies have shown that the elderly who participate in physical activities usually have better maintenance of inter-limb coordination skills (e.g., Cortis et al. 2009) and accurate upper limb proprioceptive perception (e.g., Adamo et al. 2009).

Out of the various factors concerning physical performance, different interventions have been conducted to improve motor coordination among the elderly (e.g., Pei et al. 2008; Hsu et al. 2010; Lee et al. 2015). Motor coordination includes the harmonisation of the neural and musculoskeletal systems to produce accurate movements with sufficient and balanced speed (Corbin et al. 2000; Fernandes et al. 2016). Nevertheless, old age and the reduced cognitive and physical performance capacity reduce such coordination and increase inaccurate movements (Seidler et al. 2010; Van Halewyck et al. 2015; Loehrer et al. 2016). The decline in performing motor coordination tasks is usually observed as the increased rate and increased accuracy and smoothness of movement (Aoki and Fukuoka 2010; Loehrer et al. 2016). Researchers have attempted to improve the elderly's hand-eye coordination using various interventions such as swimming exercises (e.g., Hsu et al. 2010) or Tai Chi (e.g., Pei et al. 2008; Lee et al. 2015). A possible mechanism that explains the effects of physical activity on motor coordination focuses on improving people's cognitive performance and a consequent improvement in performing such tasks. Indeed, recent studies have shown that a significant relationship exists between motor coordination and the components of cognitive performance (e.g., Fernandes et al. 2016). Though these findings were obtained in studies conducted on young children, other studies have shown that adults can also benefit from performing physical activities in terms of both improving physical fitness and enhancing cognitive functioning. (Masley et al. 2009).

Brain gym exercises are among the motor programs applied to improve the elderly's performance, and its effects on enhancing the elderly's cognitive state has been shown in previous studies (e.g., Yágüez et al. 2011). Brain gym exercises are a structured program of physical activity (without emphasising aerobics) and consists of 26 motor patterns that combine the motor patterns of eyes, head, and limbs (Cancela et al. 2015). These motor patterns somehow recall the patterns that were naturally done during the early years of one's

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life (Brain Gym® International Website 2021). The developers of the program claim that the movements are a combination of physical and cognitive exercises and improve an individual's motor performance and capability by activating both hemispheres through neurological re-patterning (Dennison and Dennison 2007; Watson and Kelso 2014; Cancela et al. 2020). Studies have shown that brain gym exercises can have positive impacts on the elderly's brain performance such as sustained attention, visual memory (e.g., Tootak et al. 2018; Yágüez et al. 2011), and cognitive flexibility (e.g., Tootak and Abedanzadeh 2021). For instance, in Yágüez et al. (2011) the patients with Alzheimer's disease that suffered from dementia showed significant improvement in terms of sustained attention and visual memory after taking part in a program of brain gym exercises. However, there is no consistency in terms of the findings obtained concerning the effectiveness of the brain gym exercises program. Some studies have indeed shown that the brain gym exercises program does not have any positive impact on the elderly's cognitive performance and physical fitness (e.g., Cancela et al. 2015; 2020). Some of the reasons for this lack of consistency is the lack of pre-test measurements to obtain a baseline criterion (e.g., Sifft and Khalsa 1991), the vagueness of the exercise protocols –including rate and duration of the exercise– (e.g., Khalsa et al. 1988), and the lack of a control group (e.g., Cancela et al. 2020).

Considering the elderly's declined performance in the motor coordination tasks (particularly in terms of the hand-eye coordination), the involved biological and cognitive mechanisms (e.g., Mahncke et al. 2006; Seidler et al. 2010), and the positive and promising evidence regarding the effectiveness of the brain gym exercises program on human's performance (e.g., Tootak et al. 2018; Yágüez et al. 2011), the current study was conducted to investigate the effects of the brain gym exercises program on the elderly's hand-eye motor coordination. Based on the claims made by the developers of the program concerning the involvement of cognitive process throughout the process of performing the motor patterns of the program and the improvement of cognitive processes (Dennison and Dennison 2007; Watson and Kelso 2014; Brain Gym® International Website 2021), the obtained results (e.g., Tootak et al. 2018; Yágüez et al. 2011), and considering the involvement of cognitive facts in performing the hand-eye coordination tasks (Seidler et al. 2010; Loehrer et al. 2016), the researchers hypothesised that implementing the brain gym exercises program can improve the elderly's performance in the above task. In addition to its potential practical implications, the study can facilitate the portrayal of a clearer picture of the field (taking into account the contradictory results obtained before).

Material and methods

Participants

In order to estimating of sample size for this study, we used G*Power (v. 3.1.9.2) software and by selecting statistical test of ANOVA: Repeated measures, within-between interaction and setting the significant level ($\alpha = .05$), the statistical power level ($1-\beta = .8$), the effect sizes according to previous background research ($\eta^2 = .3$), the number of the research groups (two groups), the number of the measurements (twice) and the mean of between measurements correlations ($r = .5$), the computed sample size was 24. Therefore, with considering of sample missing probability during practice sessions, 30 old males aged 60–80 were recruited from retirees' council of Shoush city to participate in the current study. Then, they were allocated randomly and equally to one of two groups: Brain gym exercises and control (no exercise). Some entry criteria included being above 60 and above, not suffering from Alzheimer's disease (cognitive dementia, by checking the individuals' medical file), being able to follow a set of instructions, the ability to perform brain gym exercises, not suffering severe problems in terms of movement, participating voluntarily, and filling out a consent form. On the other hand, the exit criteria were: lacking sufficient motivation, being unable to continue the exercises, and being unable to show up regularly in the sessions. All participants were provided with a written consent form approved by the institutional review board for the protection of human subjects and informed of their right to withdraw participation at any time before obtaining their consent. All procedures performed in this study were in accordance with the ethical standards of the institutional and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Instrument

Touch test disc for eye-hand coordination

The test was performed on a rectangular wooden board (120 × 60cm). There was a 20 × 10cm rectangle on the centre of the board and a circle with a diameter of 20 cm had been drawn on each side (with a 5 cm distance between the figures). The examinee had to keep his/her non-dominant hand on the central rectangle and touch the opposite circle with the dominant hand. Then, they were supposed to cross one arm over the other. Each block consisted of 25 accurate cycles, and the shortest duration of completing 3 blocks was recorded for each participant. The recordings were performed by a chronometer.

Brain gym exercises program

Among 26 movement of brain gym exercises, we selected 13 movement were tailored with current research goals. This movement and their description of how to doing have presented at Table 1.

Procedure

First, the participants visited individually with the examiner in a quiet place where the manner of performing the tests and the scoring procedures were described to them. After the pre-test stage, the experimental group performed the brain gym exercises program for 8 weeks. The sessions were held twice a week (a total of 16 exercise sessions), and each session lasted for 30 min under the guidance of an

Table 1. Brain gym exercises and related description [derived from Dennison and Dennison (1997)].

The name of movement	Description
1. Lazy 8	The ribs should be used to move the whole upper part of the body, the footprints should be followed, and the movement should be performed with the other hand, as well. You should perform it three times with your right hand and three times with your left hand.
2. Belly breathing	Place your right hand (the index finger or the palm of your right hand) on your stomach, inhale deeply through your nose, and exhale in the form of a short puff of air *via* your mouth as though you are keeping a dandelion afloat (for 1 min).
3. The energiser	First, touch your forehead with your hands and place it on the table; then, raise your head slowly. Your forehead and then your neck should follow your body, and your body and shoulder relax. While raising your chin from your chest, move your head forward, raise the back of your neck, and inhale slowly.
4. The owl	Hold your left shoulder with your right hand and move your head in the opposite direction while you exhale. Close your eyes and slowly exhale. Repeat with each hand 3 or 4 times.
5. Arm activation	Keep one hand beside your ear and involve the muscles of your arms by pressing the opposite arm. At the same time, inhale deeply and exhale after 4 s; then, change the hand.
6. Foot flex	Place your right foot on the left foot. Massage the muscles of your right leg and move upward. Then, repeat the movement with the other foot.
7. Calf pump	Place both hands on the wall, keep your front foot in a 90 ˚position, and stretch and keep straight the muscles of the back of the other foot. Repeat three times with each foot.
8. Hook-ups	The first stage can be performed both standing and sitting (stimulating the pineal body- the third eye). Close your eyes and perform diaphragmatic breathing for 60 s. Then, rub your hands to increase the electromagnetic waves, put your fingers on your belly button, close your eyes and perform diaphragmatic breathing, and press your tongue to your palate.
9. Balance buttons	The participant is supposed to touch the cavity at the base of their skull (behind the auricle) with the two fingers of one hand and place the other hand on their belly button. They have to breathe so that energy can flow upward in their body. After a minute, they have to touch the back of the other ear and repeat the activity afresh.
10. Space buttons	The participant is supposed to place two fingers of the hand above the upper lip (almost below their nose) and keep the palm of the other hand on the sacrum (the last point in their back). They have to keep the position and breathe deeply for one minute so that energy can move upward from their spine. Then, they have to change their hand and repeat the activity.
11. Thinking cap	Press the auricle with your thumb and index finger downward since it will decrease blood pressure and headache. Stretching can open the clamps of the temporal bones. Exhale while you stretch and repeat the activity 5 times a week.
12. The elephant	Use your ribs to move the whole upper part of your body. Follow the fingerprints and repeat the activity with the other hand. Perform it three times with each hand. It is claimed that the activity can increase hand-eye coordination, mental and physical activation, attention, and balance.
13. Double Doodle	The activity can be performed on a piece of paper or in the air. Draw analogous figures by both hands and simultaneously talk about their direction: outside, down, inside, up. This activity stimulates the muscles of the eyes and increases hand-eye coordination.

experienced trainer. It should be added that 4 preliminary stages were performed before the main exercises:

1. Drinking water: It is necessary to drink water before performing any exercise. That is because water forms 85% of the weight of the brain and the brain waves change 10 minutes after drinking water. In addition, drinking water facilitates the circulation of the cerebrospinal liquid that flows from the spinal cord towards the brain and vice versa (Dennison and Dennison 1997).
2. Brain buttons: The clavicle should be touched by the fingers of the right hand, and the palm of the left hand should be placed on the belly button. Air should be inhaled for 30 to 60 seconds through the nose (Dennison and Dennison 1997).
3. Cross crawl: The participant should stand up and simultaneously approach the elbow of the right hand to the knee of the left foot; then, they should repeat the activity with the reverse hand and foot. Thus, the hand and feet have to be repeatedly approached towards each other in a transverse mode. The participant can simultaneously listen to music, count numbers, or look right or left. The activity can facilitate the coordination between the two hemispheres and should be repeated several times (Dennison and Dennison 1997).
4. Hook up: The activity can be performed both in standing and sitting positions (stimulating the pineal body – the third eye). First, the participant places the right foot on the right foot, and the hands should be kept in front of the body. Then, the fingers should be hooked up in a crisscross mode, and the hands should be turned towards the chest. The activity is performed to get relaxed and should continue for 1–2 minutes (Dennison and Dennison 1997). Then, the main exercises were performed (Table 1). All the exercise sessions were held in the afternoon and exactly at the specified time. The same exercises were performed in a specified sequence during 16 sessions. At the same time, the members of the control group performed their routine activities. Finally, the participants were asked to meet again for the post-test procedure the day after the last session was held for the experimental group.

Data analysis

The mean and standard deviation were applied to describe the research variables. The normality of distribution by Shapiro-Wilk's test, and the homogeneity of variances by the Levene's test were considered. In addition, research hypothesis was investigated using the mixed- ANOVA of 2 (groups) $\times$ 2 (stages of the test), with repeated measure on last factor. The post-hoc analyses were applied in the case of observing significant impacts. All the analyses were

Table 2. Means ± standard deviation of eye-hand coordination scores in pre-post tests.

Test	$M \pm SD$
Pre-test (Brain gym)	12.96 ± 2.09
Post-test (Brain gym)	10.69 ± 1.53
Pre-test (Control)	14.26 ± 2.42
Post-test (Control)	14.37 ± 2.50

performed using SPSS 22 (SPSS Inc., Chikago, IL, USA) at $p \leq .05$.

Results

The values of the mean and standard deviation obtained for the participants' pre-test and post-test scores in terms of their hand-eye coordination in the experimental and control groups have been presented in Table 2.

As it can be observed in Table 2, the mean of the experimental groups improved significantly between the pre-test and post-test stages. The mixed- ANOVA of 2 (stages of the test) × 2 (groups) was applied to investigate this hypothesis. The necessary pre-requisites were checked before performing the test. The sphericity assumption was investigated by Mauchly's test and was approved ($p > .05$). In addition, the quality of variances was investigated by Levene's test and was approved, as well ($p > .05$). The results of the mixed-ANOVA indicated that the main effect of the test (F (1, 28) = 79.64, $p < .01$, $\eta_p^2 = .74$), the main effect of the group (F (1, 28) = 12.01, $p < .05$, $\eta_p^2 = .30$), and the interaction effect (test × group) were significant (F (1, 28) = 132.57, $p < .01$, $\eta_p^2 = .97$). The results of the paired-samples t-test to investigate the difference between the pre-test and post-test scores of the experimental group were found to be significant ($p = .0001$), while the results of the control group were not significant ($p = .27$). Moreover, the independent-samples t-test to investigate the differences between the two groups at the pre-test stage indicated no significant differences ($p = .09$). However, a significant difference was observed between the two groups at the post-test stage ($p = .0001$).

Discussion

The current study aimed to investigate the effects of performing a series of brain gym exercises on old males' hand-eye coordination. The results indicated that the elderly's participation in an 8-session brain gym exercises program (held twice a week) can lead to improved hand-eye coordination. More exactly, it was found that the experimental group (receiving an intervention in the form of the brain gym exercises) performed significantly better than the control group in terms of hand-eye coordination.

Hand-eye coordination is essential to perform routine activities and complicated sports movements. For instance, complicated tasks in basketball such as turnaround or the triple jump require hand-eye coordination and a supreme command of the situation. On the other hand, convenient hand-eye coordination is essential to perform all routine activities acceptably. The current study showed that the elderly's hand-eye coordination can be enhanced by participating in brain gym exercises sessions. The findings can be explained in terms of two perspectives. Firstly, it is possible that brain gym exercises programs improved the elderly's hand-eye coordination *via* enhancing cognitive capabilities. Indeed, studies have shown that brain gym exercises can enhance such cognitive capabilities as sustained attention and visual memory (Tootak et al. 2018; Yágüez et al. 2011) and cognitive flexibility (Tootak and Abedanzadeh 2021). For instance, in Tootak et al. (2018) 30 old males were divided into a brain gym exercises group and a control group. Then, the members of the experimental group performed brain gym exercises for 8 weeks (2 sessions a week), while no intervention was performed on the control group. The findings indicated that the elderly can improve their sustained attention by taking part in brain gym exercises sessions. Participating the brain gym exercises programs, the enhancement of one's cognitive performance, and the resulting improvement in the elderly's performance in the hand-eye coordination tasks may be an irrelevant argument. That is because people show a significant decline in performing hand-eye coordination tasks as they grow old (Aoki and Fukuoka 2010; Loehrer et al. 2016); this decline in performance is mostly attributed to the reduction of one's cognitive and physical capacity (Seidler et al. 2010; Loehrer et al. 2016). Anyway, it should be noted that it has recently been shown by Cancela et al. (2020) that taking part in brain gym exercises programs cannot lead to a significant difference from a standard exercise program. In other words, the study showed that the elderly who had been divided into the brain gym exercises program and a standard exercise program performed similarly in terms of cognitive performance, quality of life, and functional independence. Nevertheless, the lack of a control group is regarded as a major limitation in the above study. On the other hand, the higher mean of the participants (91.68 ± 8.33) compared to other studies (70.5 ± 8, in Yágüez et al. 2011; 76.85 ± 4.41 in Tootak et al. 2018) can be another probable factor for the obtained results. It could therefore be possible that the older elderly are less likely to benefit from performing the brain gym exercises tasks.

Secondly, despite the claims made by the developers of the program and the available evidence concerning the improvement of cognitive ability (Dennison and Dennison 2007; Yágüez et al. 2011; Tootak et al. 2018; Tootak and Abedanzadeh 2021), it should not be forgotten that 'movement is a door to learning' (Brain Gym®International Website 2021). In other words, in addition to the cognitive perspective, the physical activity itself that is performed during the exercises should be taken into consideration. Indeed, studies have shown that physical exercise can be quite advantageous for different aspects of the elderly's lives. For instance, they have indicated that taking part in physical activities reduces depression symptoms and enhances the quality of life among the elderly nursing home residents (Lok et al. 2017), improves the hand-eye coordination (e.g., Pei et al. 2008; Hsu et al. 2010; Lee et al. 2015), increases the maintenance of inter-limb coordination skills (Cortis et al. 2009), and increases the accurate upper limb proprioceptive

perception (Adamo et al. 2009). Taking into consideration the findings obtained in the previous studies and the current study, brain exercise programs may bring about additive benefits (i.e., physical and cognitive) that contribute to the elderly's hand-eye coordination. However, regarding the small number of studies conducted to investigate the effect of brain gym exercises programs on hand-eye coordination, it could be wise to conduct more studies to prove or reject the claim made in the current study.

Though the current study had several strengths, it suffered from some limitations. First, as an instance, only old males participated in the study. Thus, old women should be studied in future studies so that a more complete picture can be drawn regarding the effects of this exercise program on old males and females and its significance. Second, the sample size is small. Next research can select more samples to enhance statistical power analysis of their own study. Last, future research can consider other different motor tasks whose are important for elderly's health life style. This approach gives us comparison power between probably different effectiveness the brain gym exercises on different motor tasks, and this induce better decision-making for selecting best exercises in this area.

Conclusion

In general, the current study indicated that a course of brain gym exercises has beneficial impacts on hand-eye coordination. Due to the elderly's declined cognitive and physical performance (particularly in terms of hand-eye coordination tasks), the findings of the current study can have useful practical implications for occupational therapists and people who deal with the elderly. Nevertheless, it should be repeated that the number of studies conducted in the field is quite limited, and more studies with various tasks and the elderly in different age ranges should be conducted.

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Data availability statement

It should be noted that the data of this research is available and will be shared as soon as there is reasonable request.

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